Research Report 1224

LEVEL II

EARLY TRAINING ASSESSMENT WITHIN DEVELOPING SYSTEM CONCEPTS

Charles C. Jorgensen

ARI FIELD UNIT AT FORT BLISS, TEXAS

U. S. Army

Research Institute for the Behavioral and Social Sciences

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WILLIAM L. HAUSER
Colonel, U S Army
Commander

JOSEPH ZEIDNER
Technical Director

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This paper presents a proposal for training assessment within early system concepts. A broad spectrum of training requirements generated by recent Army guidance for determining training impacts at the earliest stages of weapon system specification is considered. An examination of the state of the art is made along with recommendations for six methodological areas: concept generation, task specification, trade-off analysis, management information, system effectiveness estimation, and costing. Innovative and little known techniques

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Charles C. Jorgensen

Submitted by:
Michael H. Strub, Chief
ARI FIELD UNIT AT FORT BLISS, TEXAS

Approved by:

E. Ralph Dusek
PERSONNEL AND TRAINING
RESEARCH LABORATORY

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333

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FOREWORD

Both the Deputy Chief of Staff for Personnel (DCSPER) and the Training and Development Command (TRADOC) have expressed a strong need to examine the training and personnel requirements of weapon systems under development. To reduce training costs, the assessment of training impacts must begin as early in system development as possible. OMB Circular A109, Major Systems Acquisition, has set early estimation as a major policy goal. In order to aid the Army in meeting these needs, the ARI Field Unit at Fort Bliss has begun a research program aimed at the development of an early training assessment technology. The problem is a complex one touching many areas of man/machine interactions.

The research reported here considers a broad spectrum of training derivable at the earliest stages of weapon system specification. An examination of the state of the art is made, with recommendations for six areas of training research: concept generation, task specification, trade-off analysis, management information, system effectiveness estimation, and costing. Innovative and little known techniques include both tri-service and foreign research. A proposal is made for combinations and extensions of existing research to meet projected Army needs. Areas in need of further research are identified.

This research is in response to requirements of Army Project 2Q762722A777 and special needs of the Directorate of Combat Developments, Fort Bliss, Tex.

Joseph Zeidner

JOSEPH ZEIDNER
Technical Director

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EARLY TRAINING ASSESSMENT WITHIN DEVELOPING SYSTEM CONCEPTS

BRIEF

Requirement:

To investigate estimation of training requirements for weapon systems in early conceptual development.

To propose a methodological framework for estimation of training that includes existing and developing research.

Procedure:

System development impacts, threats, hardware, and training needs were outlined for developing systems. Six methodological areas were evaluated: concept generation, task specification, trade-off analysis, management information, effectiveness estimation, and costing. Strengths and weaknesses were considered for each area. Ways of merging existing techniques were elaborated. Future research areas were identified.

Findings:

A workable structure in which an early training estimation procedure could be developed was generated.

Utilization:

This report can be used to help specify requirements which should be met by a procedure for estimating training. Background material draws on tri-service as well as foreign efforts with detailed cross referencing to current Army regulations.

It is concluded that an early training assessment system is within the range of developing technologies.

EARLY TRAINING ASSESSMENT WITHIN DEVELOPING SYSTEM CONCEPTS

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INTRODUCTION

System Development Impacts

The growth of complex military systems has created a corresponding need to improve estimation of system concept impacts and costs. During the mid-1960s, the Army recognized that serious shortfalls existed due to the fact that trainer and user requirements had little influence on the early development and fielding of most materiel systems (Gross, 1977; Knauer, 1977; Krebs, 1977; Taylor, 1975). To remedy that situation, in October of 1968 the Army published DA Pamphlet 11-25, Life Cycle Management Model for Army Systems. Revised in 1975, this 119 event flowchart for system development has three major areas of emphasis:

1. The development and acquisition procedures for Army Systems beginning with concept investigation and continuing through disposal of obsolete equipment,

2. Generation of a framework within which supporting models and publications can be developed, and

3. The creation of a management structure for coordination of combat development, R&D production and logistics support, personnel requirements, training, and maintenance of weapon systems.

In this complex document, each developing system is placed into one of four major categories:

1. <u>Conceptual</u> where concept development and prototype generation take place,

2. <u>Validation</u> where verification of preliminary concepts takes place and trade-offs and operational tests begin,

3. <u>Full scale development</u> where the system is completely engineered, fabricated, tested, and integrated with human requirements including personnel, documentation, doctrine, and organization, and

4. <u>Production and deployment</u> where operational units are trained, equipment is provided, and logistics support is established.

In May 1978 at the "Atlanta V" conference on Systems Acquisition Perspectives (1978), General Robert J. Baer, Deputy Commanding General for Materiel Development, noted that recent Army documentation such as OMB Circular A-109 (1976) forces a concentration on the front end of the acquisition cycle and requires frequent reevaluation of changing military threats. He stated that there is a growing need to obtain improved estimation methods for developing systems to reduce the life cycle period from the current 17-20 years.

Part of the driving force in General Baer's focus on early stages of system development was that human factors considerations are most cost effective if they can be identified before hardware development restrains the freedom of potential training systems. After physical dimensions and characteristics have been set, a sequence of events is put in motion that ripples throughout a weapon system and results in marked increases in the cost of changes. Figure 1 illustrates one way in which the flow of developmental events may be visualized.

Threats

The initial driver of system development begins with a perceived enemy threat and a derived hardware concept and mission to overcome that threat. The basic Army regulation dealing with threat analysis is AR 381-11. Threats are broken into three periods: short-range (0-2 years), mid-range (2-10 years), and long-range (10 years and beyond). Threat analysis has five stated purposes:

1. To provide an assessment of foreign capabilities in terms of combat materiel, employment doctrine, environment, and force structure;

2. To provide an assessment of the level of development which the economy, technology, and military forces of a country have or could attain;

3. To affect U.S. planning or development by extending or by supplementing available intelligence estimates or validated force deficiencies;

4. To provide a statement of a threat as it relates to a specific U.S. research or combat developments project; and

5. To fill gaps where data are lacking or evidence is too inconclusive to permit an intelligence estimate.

Within the Department of the Army, the Office of the Assistant Chief of Staff for Intelligence (OACSI) provides threat products for dissemination. For systems under development validated threat scenarios are required. (These are described in greater detail in AR 10-5.) Generation of the threat details is treated as an intelligence function.

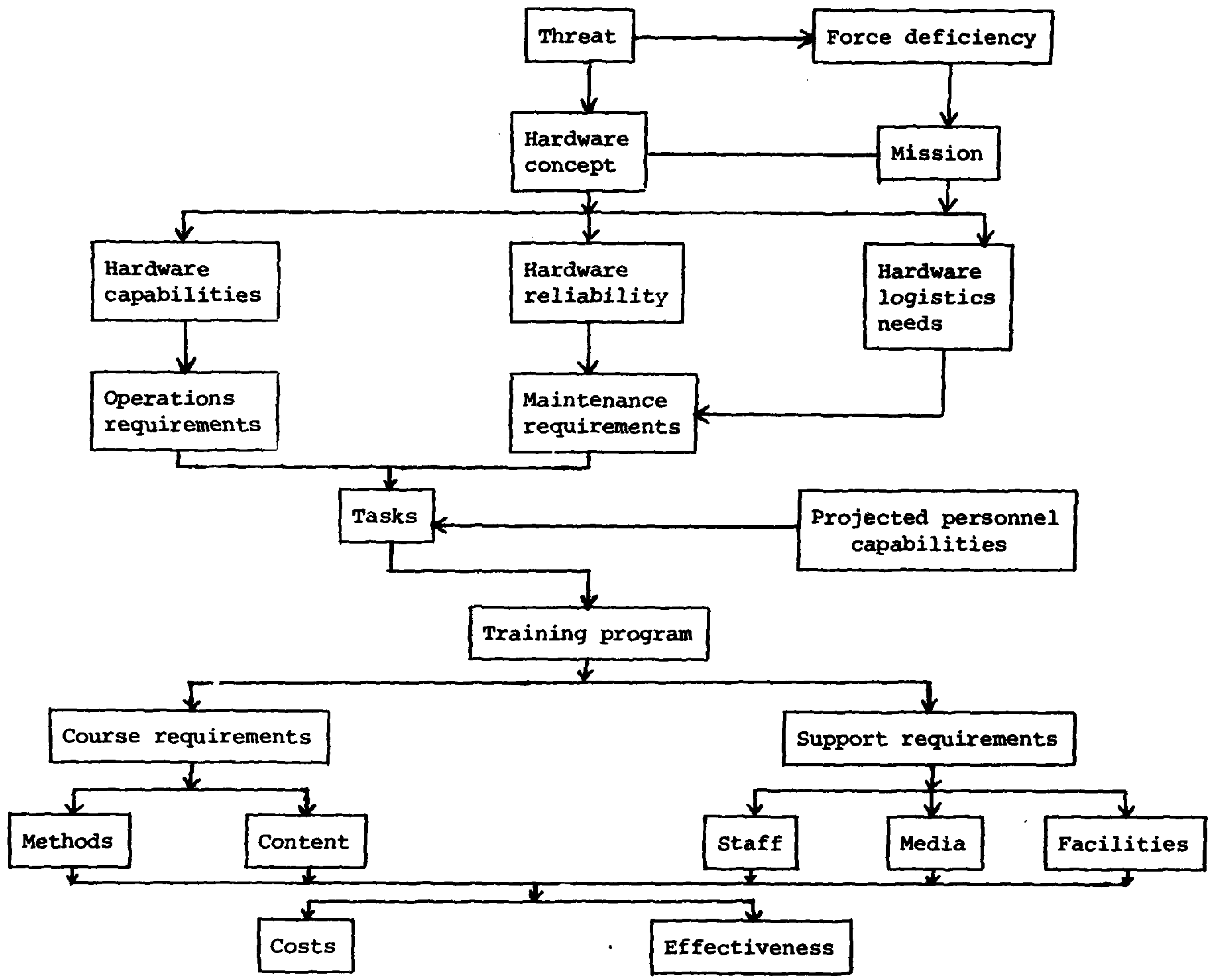

Figure 1. Impacts of early development areas affecting training.

However, the assessment of the impact of a given threat on Army plans, studies, projects, and systems is not. The main two documents related to early developmental studies are AR 5-5 (study plan guidance) and AR 70-27 (the threat interface development plan).

Based upon a threat and the current force deficiency, possible hardware concepts are defined. These initial concepts drive the later life cycle events which include training related issues. Materiel concept investigation is generally initiated through one of two sources. First, a materiel developer may achieve a significant advance in technical capability and knowledge. Second, the combat developer may obtain a validated capability goal. An example is a goal established at HQDA to counter a validated threat, to correct an operational inadequacy in existing materiel, to reduce high consumption of resources, or to exploit a technological breakthrough. Capability goals are in turn derived from a variety of sources such as national policy guidance, Army readiness postures, simulations, studies, war games, or other analytic research. This process is considered in detail in AR 71-9, AR 70-1, and AR 1000-1. For this paper, Figure 1 sufficiently illustrates how a developing equipment concept begins to effect system training.

The operation of a new system is driven by the physical characteristics of the system hardware. Hardware characteristics such as reliability, physical dimensions, and resource needs impact directly on the human users through operator and maintenance requirements. These requirements are reflected in the tasks which must be performed. The tasks combine with available personnel capabilities to determine the training approach required. The approach flows from the need to meet performance objectives generated by the threat and mission. Performance objectives in turn drive a course structure and a support structure. The course structure includes the method and content for training the specific personnel. The support includes the facilities, associated staff, and media.

Hardware

The flow of system hardware development therefore leads to training and personnel impacts. In terms of the Life Cycle Management Model described in AR 11-25, the early training system impacts are two events in AR 11-25; number 4 (training plans) and number 5 (organizational and operational concepts). Training plans are developed by the designated training group in coordination with the materiel developer, Combat Developer and Logistician. Details of this process are found in AR 71-5 and AR 611-1. In general, events 4 and 5 interact with the materiel system in two ways. First, training demands can be produced by changes in the design. Second, a strategy chosen for training on a particular design concept can require that skilled personnel must be available when the system is deployed. As stated in AR 11-25:

Training plan action during the conceptual and validation phase is oriented toward the establishment of training considerations which will influence the design of equipment and identify training implications that have an impact on material readiness, capability and overall cost. Planning during development centers on analysis and evaluation of alternative training concepts. The training plan identifies critical areas and contributes to availability and maintainability objectives as well as requirements for inclusion in the Outline Development Plan and the Development Plan. Planning includes all methods, media, devices, skill qualification tests, training extension courses, and simulations required for institutions and units.

Organizational and operational concepts are the responsibility of the Combat and Materiel Developers. The emphasis is on organizational, equipment, and personnel trade-offs that would be required if the system concept is included in the total force structure. The result of trade-off studies serves as the basis for the Provisional Qualitative and Quantitative Personnel Requirements Inventory (PQQPRI), Doctrinal and Organizational Test Support Package, and Basis of Issue Plan. Greater detail on these areas may be found in AR 1-1, 71-9, 71-2, 570-2, and 750-1.

Although the Life Cycle model includes the entire system cycle, this paper examines only the research implications of AR 11-25 events 4 and 5. It is evident that many of the training aids now being developed for validation and later stages are directly effected by the *quality of projections performed* at early stages. As a reflection of this relationship, efforts are ongoing to improve the data bases. These efforts include the TDIS (Training Developments Information System) being set up at Fort Eustis, Va., and the LSAR (Logistics Support Analysis Record) at DARCOM and CODAP (Comprehensive Occupational Data Analysis Programs). However, the implications of early inclusion of training and human factors considerations go far beyond data bases. As illustrated in Figure 1, components are interrelated, so changes in one area produce impacts in many others. This has direct implications for the needs which future R&D must address.

Training

Figure 1 showed a general overview of training flows. If attention is limited to the training-related breakout of the implied operations, Figure 2 can be derived. Based on threat and current operational capability, a deficiency is identified. The deficiency leads to a system need concept which includes materiel, support, and doctrinal and organizational capabilities. From these capabilities a system description is derived including the human functions which must be performed. Figure 2 traces the utilization of these functions as they impact training development. Statements about system purpose can be broken into two parts: general operations which represent global system capabilities and

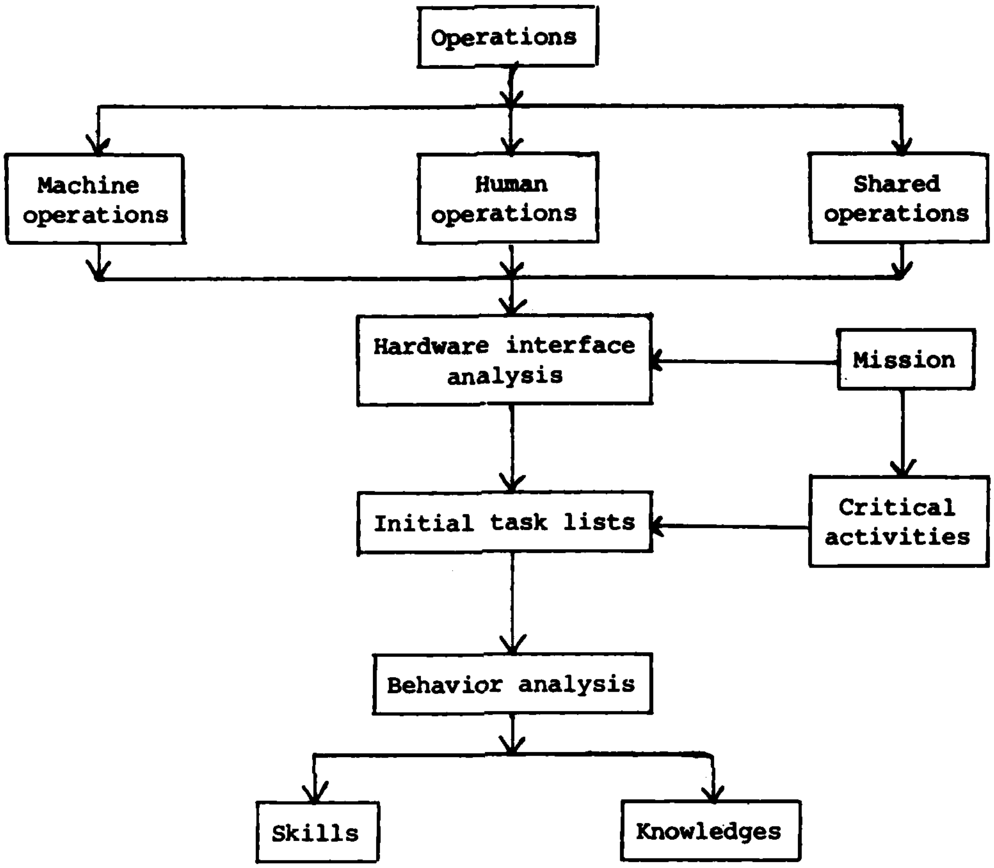

Figure 2. Breakdown of conceptual operations.

specific operations which are related to the mission scenario within which the system will be utilized. General operations can be broken into three groups: machine only, mixed, and human only. When a mission is considered, it is possible to identify critical operations in terms of their effect on the threat. The interface between the developing hardware and the operational groupings become the first place where improved assessment techniques resulting f R&D could have major impact. Pending a trade-off result accorc j to event 5, the output of this interface feeds more detailed training analysis.

The global operations are then redefined in terms of the specific activities required for their performance. The activities lead to human behaviors which can be broken into skills and knowledges. One way this breakdown could occur is presented in Figure 3. Activities are separated into training requirements based on required skills, knowledges, and projected personnel characteristics. Based on mission critical tasks, a training mode analysis takes place which sorts activities into equipment intensive or personnel intensive training. The former refers to training devices such as embedded training or simulator generation. The latter refers to training procedures sensitive to interpersonal factors such as role-playing techniques or tutoring. Equipment intensive analysis provides a second point at which training development and hardware development intertwine and where R&D efforts need to be applied.

SELECTED METHODOLOGIES

Overview

Heretofore, the flow of information during concept development has been considered in terms of impact in general training areas. Now specific research efforts will be addressed. Conclusions will be drawn regarding what remains to be done and preliminary suggestions will be made for completing an early training assessment system (ETAS).

The focus of this examination will be on processes having the greatest impact on the training areas in Figures 2 and 3. For simplification, research efforts will be evaluated under the following headings:

1. Concept generation,
2. Task specification,
3. Trade-off analysis,
4. Management information,
5. Effectiveness estimation, and
6. Costing.

The above topics cover prohibitively large areas of research. It would go beyond the purpose of this review to attempt a discussion of all tri-service research efforts. Instead, a small number of high quality studies dealing with each of the above topics have been

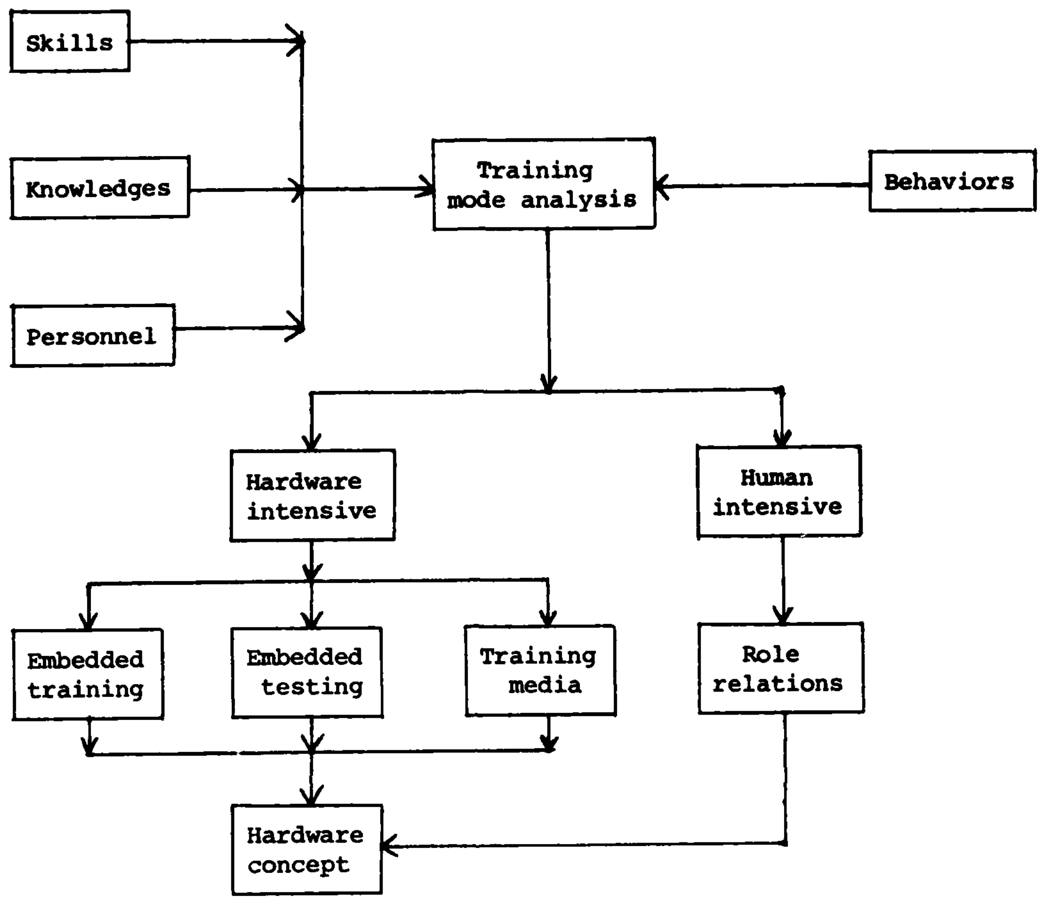

Figure 3. Training mode analysis.

considered. These were selected to integrate into a comprehensive set of technologies needed during early conceptual development stages. The benefit of such an approach is that areas still lacking research become more obvious than if individual topics were considered piecemeal. The disadvantage is that the research screening process might omit significant studies whose true value may not become evident until they are placed in the light of an overall pattern. It is hoped, however, that the benefits of producing the overall pattern will make up for loss of specific elements.

The first topic to be considered is conceptual generation. Generation means the production of the initial system concepts based on the perceived deficiencies between the threat and the current operational capability. As illustrated previously in Figure 1, a threat leads to an examination of available hardware and projected future technology which can be applied to create new hardware systems capable of meeting a mission deficiency. Physical characteristics, reliability, and logistics needs are derived from a hardware concept. From the standpoint of the psychologist, the question to be asked is "how does the concept developer construct the first estimate?" Particularly, how does the documentation produce impact on the later needs of a training analyst?

Concept Generation

If training analysts are to enter into the development process early, they must be able to communicate with the hardware designer so the needs of both can be freely exchanged. This in turn requires a common language through which both parties can communicate. This is true not only for the interaction between training and hardware development but also between analysts of each group. In the past such communication has not always taken place. This is often due to the fact that technological breakthroughs may be known only to limited groups of people within a particular scientific area or industrial firm. A large percentage of past efforts have resulted from unsolicited proposals or individual interactions between the military and civilian community. The exception to the rule is when a perceived threat leads directly to the generation of a Mission Elements Needs Statement (MENS) or Science and Technology Objective Guide (STOG) which is let out for potential submissions. A problem with this system is that communication becomes difficult as more and more affected parties are brought into the developmental cycle. Neglecting specifics of how an initial design is produced, the first problem is design description to maximally integrate the input needs of all Army personnel. This problem encompasses a large range of psychological research. In terms of training development, a driving factor is that descriptions must lend themselves to the eventual production of tasks and their associated learning objectives. This has direct implications for the way equipment design must take place. There are at least two research efforts which could be used to improve design communication.

ECSL. The first is a simulation language called ECSL (Extended Continuous Simulation Language) (Clementson, 1978) used primarily in Great Britain. ECSL is unique in several respects. First, it was developed as a result of communication problems between designers and oil company executives during drilling operations in the North Sea. It became evident that it was impossible to communicate in highly technical hardware terminology to nontechnical personnel responsible for system coordination. To remedy the problem, a common graphic mediator was developed by which each user could make his/her understanding of the system specific by means of a graphic analogy called activity networks. Similar to scribbles on a blackboard, the activity networks broke down the world into objects waiting to perform actions and the actions themselves. This mediator permitted rapid communication of underlying relationships regardless of the particular terminology which was used by each group. To study the implications of a given system configuration, ECSL was developed as FORTRAN-based language through which activity cycles could be simulated. Thus, a concept could be recorded quickly into a form suitable for dynamic exploratory testing.

CAPS. The researchers did not stop here however. The next step constituted a major breakthrough in the use of simulation. Recognizing that most simulation languages such as ECSL are far too complex for the average user, a user-transparent machine interface called CAPS (Computer Aided Programming System) (Bailey, Pash, & Watts) was created which permitted the user to specify the activity cycle interactively with the computer once a system configuration was proposed. Once a network was produced and self-checked by the computer program for consistency, the CAPS automatically converted the model to ECSL code resulting in an immediate error free simulation! The implications for training development are enormous, including many possible uses of rapid simulation in military problems. Through CAPS the training developer and the hardware developer can not only share a common conceptual language, but the result of changes can be immediately evaluated in trade-off simulations.

CAPS provides a well-developed capability for improving communications between the trainer and the hardware developer. It is well documented although acquisition would still require foreign contacts. In terms of future needs CAPS does have limits as a result of the activity cycle format and the ECSL base language. Tremendous advances are possible if the same concept were to be expanded to determine an optimal military interface language. This would require a specialized human interface such as CAPS for communications between hardware developers and trainers. The Fort Bliss field unit is presently exploring CAPS as well as research requirements for optimal simulation language selections as part of an ILIR (Independent Laboratory In-House Research) effort. Many psychological research problems remain; however, this relatively unexplored area could provide great benefits since early improvements in system formulation ripple throughout the life cycle at ever increasing costs.

THOUGHTSTICKER. A second interesting effort being conducted under an Air Force Office of Scientific Research 6.1 contract is called THOUGHTSTICKER. THOUGHTSTICKER is a computer-regulated concept interrogation and recording device. At one level of analysis, this system encourages a user to output an explanation or justification of each concept and then checks that the user output satisfies rules of consistency and complete cycles of logic. A completed cycle is called an entailment mesh. It permits the use of graphic analysis techniques to simplify redundancies and helps focus a designer concept. A second user mode exists which permits the designer, after an entailment mesh has been produced, to defend design decisions by suggesting generalizations which analysts may accept or reject. If analysts reject these generalizations, they must supply a logical reason, forcing consideration of alternatives. In overview THOUGHTSTICKER is interfacing hardware combined with computer programs and consists of 10 functional components:

1. A mesh display on which the user writes concept derivation paths;

2. A graphic display tube and console used to present modified meshes, as well as to elicit descriptor values (Results of over generalizing system heuristics such as "extrapolation of principles" are output to users as proposals through this display. The current system uses two displays.);

3. A terminal input device for user control;

4. Files for entering demonstration materials for topics (Clusters of signal lamps referencing each file have different meanings to the user at different phases in the process, e.g., to indicate the status of a topic or all simplifications.);

5. A joystick, used to point out topics on the graphics display tube (For example, topics for which files are to be updated.);

6. A descriptor display also used to present indexed items or topics which are subsequently associated with other topics on request;

7. An item indexing board for descriptor elicitation and external regulation of the system;

8. Computer and interface hardware (for operating peripherals);

9. A display for exhibiting photographs of previous stages in the process; and

10. A board for retrieving and displaying data structures of previous stages.

In a typical utilization, a designer produces an entailment mesh under the constrained conditions above. He then modifies the mesh as a result of being forced to examine assumptions and generalizations. Finally, the system requires the user to describe the mesh by citing descriptions (actually many valued sets of descriptive variables) as relevant or irrelevant. Critical conditions such as design reliability, ease of understanding weight, cost, size, and environmental sensitivity are required as mandatory descriptors. The final design mesh leaves a standardized form for use by others much as the activity cycles provided a standard input for CAPS.

Future Research Needs. THOUGHTSTICKER is a developing system used primarily in the context of electrical engineering although it has potential in other areas. This is also a foreign effort. Its greatest value lies in illustrating the feasibility of creating a designers aid which can automatically standardize a description within which system concepts can be developed. Research is needed to produce an advanced system oriented for military concept development. Research must also explore the relationships between network structures based on hardware or conceptual designs and the resulting impacts on networks of tasks. The use of such a network will be discussed in detail in a later section.

During early system development, a system such as THOUGHTSTICKER could provide an answer to a variety of problems associated with assessing training impacts. The ability to prestructure conceptual development and to produce a transportable output could provide immediate benefits via wider distribution of early system concepts. System ideas could be developed more easily in team efforts where THOUGHTSTICKER or a CAPS system could provide standardization of output forms for both equipment and task derivations. The task implications of a particular hardware concept could be explored as an integral part of an activity network or entailment mesh. Computerization of this data base could permit rapid changes or updates as threat-driven modifications are required. This possibility leads to a requirement for determination of what information should be included in a task base derived from early conceptual configurations. These needs will now be considered.

Task Specification

A much larger quantity of research exists for task specification; however, many of the efforts are not system oriented to the extent that subprocesses can be broken out for use with other training developments. Two efforts will be considered which do hold promise however.

Task specification actually includes several subareas, all of which ultimately are derived from implications of hardware configuration and the definition of expected usage. The following derivation can be made. The mission plus equipment leads to patterns of usage. These patterns of usage can be broken up into specific behaviors. The behaviors in turn can be broken down based on mission-based objectives such as who does what to whom, how, when, and how well. Based on an estimated profile of a typical human user, the projected deficiency between the user skills and knowledges and the behavioral objectives lead to training deficiencies. Training deficiencies are used along with system objectives to select training methods, strategies, and constraints. To perform such a selection, objectives must be evaluated in terms of constituent tasks. The tasks are in turn analyzed through various relations and values which they maintain in respect to system hardware.

The major process by which Army training objectives are currently being produced is through the Army Instructional System Development (ISD) procedures contained in the TRADOC 350-30 series of documents. These documents provide an overview of the training development process but still lack much detail by which specific training development objectives must be met. In terms of the development of early training assessment it becomes important to find analytic procedures which can be linked directly to system concepts.

The SAT Program for the B-1 Bomber. A most comprehensive effort in training system development is contained in some work performed by the Calspan Corporation under contract to the Advanced System Division of the Air Force Human Research Laboratories at Wright Patterson Air Force Base (Ring, Startz, Gaidasz, Menig). Major aspects of this work which bear directly on early system specification will be discussed. The Systems Analysis of Training (SAT) approach uses two sets of information as a starting point. The first is a catalog of display and control information derived from a specified system concept. This computerized catalog includes seven pieces of information:

1. Control and display names,
2. Synonyms for names used in number 1,
3. Subsystem identifiers for equipment locations,
4. Physical locations of the controls,
5. Types of displays,
6. Values or range which the displays can assume, and
7. Additional clarifying comments.

Based on the display catalog equipment and a mission scenario, tasks are inferred by breaking gross classes of actions into four levels of detail. In descending order of inclusiveness they are

1. Mission segment (such as reload a missile),
2. Function (such as drive reloading vehicle),
3. Task (such as start reloading vehicle), and
4. Task element (such as turning a key).

The lowest category (4) is subdivided into a series of information strings based on behavior type, timeline or sequence, and crew interactions.

There are nine components in a SAT task element description. They are

1. Title,
2. Number,
3. Person performing,
4. Behavior category,
5. Duration,
6. Crew interaction,
7. Previous task elements,
8. Next task element, and
9. Comments.

The latter information (9) presents an extremely valuable source of unclassified factors that may impact the program. In the context of the earlier discussion, elements 1 through 9 present the first estimate as to what kind of information should be considered in the conceptual development for the entailment mesh or CAPS simulations discussed earlier. For example, it should be possible to program a THOUGHTSTICKER-like system to interrogate and check a development team for all the elements in both tasks and equipment tables at the same time. This could lead to the production of a first pass task and equipment list for examination by combat developers, training developers, or required contractor personnel should the information be used to guide the generation of a detailed statement of work. An example of the behavioral elements such a system would require is given in Figure 4. A sample format for task information also taken from the SAT reports is presented in Figure 5.

Much work must still be done before a preliminary assessment of a training program could be produced. Based on a format such as that used in SAT, task information must still be broken into behavioral objectives. The SAT procedure accomplishes this as follows. First, task element data are partitioned into behavioral components. The components are labeled as either skills or knowledges. Skills are defined as observable actions requiring physical coordination. Knowledges are defined as covert responses with five levels:

1. Identification,
2. Recall,
3. Interpretation,
4. Calculation, and
5. Prediction.

Skills and knowledges are then grouped on the basis of categorical commonalities into behavioral objectives. A behavioral objective is considered to have 11 parts (see Figure 2). They are

1. Title,
2. Initial conditions required,
3. Concurrent behaviors,

OBJECTIVE:	Title of Objective
INITIAL CONDITIONS:	State of the Air Vehicle (e.g., climbing at 2000 ft./min., electrical power available, etc.)
CONCURRENT BEHAVIORS:	Overt or covert behaviors conducted simultaneously with the objective behaviors (e.g., maintain constant heading through maneuver)

BEHAVIORS:

INITIATION CUE					COMPLETION CUE		
CONTROL/DISPLAY	RELATION	VALUE	ACTION VERB	CONTROL OR DISPLAY	CONTROL/DISPLAY	RELATION	VALUE

PERFORMANCE:	Criteria for demonstrating proficiency
ENABLING OBJECTIVE:	Skills and knowledges necessary to enable the trainee to perform the behavioral objective within the specified performance limits
ANCILLARY OBJECTIVES:	Skills and knowledges necessary to handle abnormal events
OPERATORS:	Who is performing the behavior
INTERACTIONS:	Crew coordination
TASK ELEMENTS:	Task elements incorporated by the objective
OBJECTIVE CRITICALITY:	On a three-point scale
OBJECTIVE DIFFICULTY:	On a three-point scale

Figure 4. Behavioral objective format taken from SAT reports.

Format:

Conjunction	Initiation cue			Action verb	Control or display	Completion cue		
	Control/ display	Relation	State			Control/ display	Relation	State

Format of task element behavior

Example:

Behavior:
Setting wing sweep angle for cruise configuration

Conjunction	Initiation cue			Action verb	Control or display	Completion cue		
	Control/ display	Relation	State			Control/ display	Relation	State
	Altimeter	=	30000			Wing sweep indicator	=	45
AND	Power level indicator	>	90	Adjust	Wing sweep control			

Figure 5. Example of task element behavior taken from SAT reports.

4. Performance criteria,
5. Other competing objectives which must be met,
6. Unusual conditions,
7. Operators used,
8. Interactions required,
9. Task elements accounted for by the objective,
10. Criticality to mission, and
11. Difficulty to perform.

The final step is to again group task elements into processing blocks on the basis of common behavioral objectives. The methods by which this is accomplished are not as well developed in the SAT program.

Future Research Needs. In its current form, SAT consists of a variety of computer-aided data base programs and manual coding forms required for task evaluations and requires expert support or evaluation. The real value of this work has, in the opinion of the author, been overlooked possibly due to the cancellation of the B-1 program. There is a great deal of theoretical and applied information which has not been considered here but which could have beneficial application in other training areas such as Cost and Training Effectiveness Analysis (CTEA) (TRADOC Pamphlet 71-10, 1977). Some developmental work is needed to adapt the formats to Army needs and interface between the final concept form and the SAT logic for going from mission to behavioral objectives. Effort would be required in order to determine whether expert intervention would still be required based on the state-of-the-art in task derivation. Nevertheless, the SAT work represents a significant advance in many of the problems now developing in proceduralized training estimation. The SAT work is somewhat unique in that a comprehensive and systematic effort was made to carry the initial logical framework through to the actual generation of a training system for a weapon that was still under early development. For that reason, it deserves close examination.

Trade-off Analysis

In the section on task generation, it was noted that expert intervention was required in system conceptual development as well as specification of tasks and behavioral objectives. An important area directly related to intervention includes hardware and training trade-offs. These are generated by dollar costs and functional requirements inferred from estimated battlefield effectiveness. Trade-offs can be considered at two levels. The first deals with the relationship between system candidates and total battlefield posture. This level is considered under the Army requirements for Cost and Operational Effectiveness Analysis (COEA) (TRADOC Pamphlet 11-8). As illustrated in Figure 1, the selection of equipment configurations leads to the later requirements for human performance capabilities and training programs. Training suitability is reflected in the need for early adjustment of potential systems in order to minimize cost impacts. Training assessment has been given the name of Cost and Training Effectiveness Analysis or CTEA. At one level, CTEA is intended to provide evaluative information of cost and projected effectiveness for new training systems. In terms of input to COEA these analyses can result in the acceptance or rejection of a new system concept during early development if it can be shown that the system has an unacceptable resource or cost impact on training. CTEA has highlighted the Army need for estimation of the effect of potential training systems as well as changes within already existing systems or system concepts. Since trade-offs for both training and hardware are an inherent characteristic of early life cycle development, it is important that the training developer has tools to assess the impact of changes suggested by the hardware developer. This brings the question back to how the impact of alternate system components should be assessed. One way already suggested is to use the output of CAPS as a system simulation. While this may work in a very early COEA context, it may be too crude for making specific training decisions. This paper will not examine research which addresses training decisions.

LCCIM/TRAM. The first technique to be discussed is Life Cycle Cost Impact Modeling System (LCCIM) (Baran, Czuchry, & Goclowski, 1978). LCCIM was part of an Air Force effort called DAIS (Digital Avionics Information System) (Czuchry, Doyal, Frueh, Baran, & Dieterly, 1978) which resulted from a need to assess potential impact of avionics integration on weapon system life cycle cost and system support personnel requirements. The DAIS effort went beyond original project goals to consider both system design and modification phases (Digital Avionics Information System). The developing LCCIM concept consists of three submodels and associated data banks which operate either interactively or independently. The first is a reliability and maintainability model which traces support maintenance operations at the unit, subsystem, or system level to produce point estimates of human resource requirements. According to the authors, it can also identify sources of high resource consumption and answer "what if" questions concerning the expected results from changing values of reliability and maintainability parameters.

The second submodel is a system cost program which aggregates components of system life cycle cost and presents them either in selective combination or summary form. This cost process already has several good analogs within the Army which could probably be applied quickly when needed without having to adopt the accounting schemes used by the Air Force or Navy (Braby, Henry, Parrish, & Swope, 1975) programs.

The third submodel is perhaps the most interesting from the standpoint of the psychologist and parallels well-developed research within ARI on the training developers decision aid (TDDA) (Pieper, Guard, Michael, & Kordek, 1978), TRAINVICE (Wheaton, Rose, Fingerman, Korotkin, & Holding, 1976), and the Fort Bliss CTEA selection methodology (Jorgensen & Hoffer, 1979). TRAM (Training Analysis Model) (Digital Avionics Information System) includes three modules:

a preprocessor and two analytical modules for training plan and training program generation. To function, the model requires an existing data bank containing the set of tasks to be learned. The generation of the data bank is not detailed as in the SAT effort considered earlier.

The generation of such a bank for the Army still remains a problem. The Army does have several ongoing efforts to produce information banks for developer systems. One consists of the application of CODAP Comprehensive Occupational Data Analysis Programs developed by Phalen and Christal (1973). A more recent effort for earlier systems is the LSAR or Logistics Support Analysis Record being developed and utilized by DARCOM. A third effort still in preliminary stages is an attempt to unify task information in a single data bank across MOS's for Training Development Information System (TDIS) at Fort Eustis, Va.

Returning to the TRAM model, the task data banks are subject to user-defined specifications which allow the assignment of five descriptor values denoting frequency, criticality, learning difficulty, taxonomy, and sequencing. This information is input into a preprocessor which screens the total set of tasks in a series of "go" or "no go" decisions to select those to be used for training. The output of the selection process is used to feed another module which is a training plan generator. Based on a series of real world constraints including the number of personnel required, maximum allowable training cost, and maximum allowable time, the generator produces an initial training plan in which a School/OJT mix is determined. This is followed by recommendations concerning appropriate methods and media. The process appears to require a high degree of manual and expert intervention. The TDDA model may possess a better mix of skill requirements for Army utilization in this area.

TEEM (Training Efficiency Estimation Model). A second model to be considered for trade-off analysis is the ARI CTEA work (Jorgensen et al., 1978). Since CTEA is inherently oriented toward upper level decision makers some form of trade-off analysis is critical. Currently, ongoing efforts at Fort Bliss have focused on two areas. The first area includes major cost impacts. ARI is using a modified form of the Navy Training and Evaluations Groups cost program (Braby et al., 1975) or Training Evaluation Cost Evaluation Program (TECEP). Although being well suited to overall cost analysis, TECEP does possess some weak points in that it is not oriented toward an average cost accountant but rather is more of a theoretical model of economics. Problems are currently being resolved by the Army Air Defense School. The TECEP model does provide a good starting point for cost estimations at early stages in system development. As systems become more developed, a more general life cycle cost model would probably have to be used.

The second focus of the Fort Bliss work involves the Training Efficiency Estimation Model (TEEM) research. The TEEM (Jorgensen et al., 1975) is the result of in-house efforts to determine the efficiency by which training resources are being utilized to meet psychological requirements during early training program media and method selections. The efficiency metric is described in detail in Jorgensen and Hoffer (1978) and tracks the degree of fit between task descriptions and training hardware selections. It could form a basis for a trade-off analysis procedure in early system estimation. Some contract efforts in this direction are already underway.

MODIA. A third work which should be considered in this area is the MODIA model developed by the Rand Corporation (Carpenter, 1978). Method of Designing Instruction Alternatives (MODIA) has as its primary purpose the improvement of training resource utilization. MODIA has four components:

1. A description of various options for course design,

2. A user interface to facilitate use of noncomputer oriented personnel,

3. A resource utilization model, and

4. A cost model.

Expert intervention is provided at two points in MODIA: the user interface and the cost model. The description of options for actual course design is in a separate manual. The resource utilization model is a stand alone computer mode. Regarding functions, the first component introduces the user to the required data for the model, the choice options which will be available when the interactive user interface is run, and the pros and cons of the various training choices as the authors see them. Component two produces interactively refined course descriptions that include content, teaching strategy, student characteristics, and physical resource assignments. The interactive nature of the procedure is valuable because it allows the users to see the impact of trade-off decisions they have made at each stage of the process. Component three simulates student progression through the course structure developed in stage two and generates impact requirements from student flow patterns over time, waiting times for required resources, and demands upon existing supplies and facilities. The fourth component consists of a cost model which estimates 5-year investment and operation costs.

To use the MODIA system, two groups of individuals are required. The first is a small team highly familiar with the logic and operation. The second group includes subject matter experts who are normally used in course development. Working as a team, these two groups answer a series of questions asked by the system via the user interface program. There are eight areas which are included in these questions. They are (a) the training objective list, (b) the subject matter type (such as team, individual, or classroom), (c) the training examination characteristics (such as failure rate expected), (d) the student population characteristics (such as arrival times, group size, and ability level),

(e) the teaching policy (including the number of course tracks, the content diversity, and learning events), (f) the teaching method, (g) the test characteristics, and (h) the physical resource demands.

Future Research Needs. MODIA appears to present possible sources of training information, particularly in the resource utilization model. In terms of immediate Army usage, many of the variables are highly dependent on the subjective abilities of the training analyst who is using the system. MODIA's value may lie more in the area of program management than in actual course development and could be beneficially applied for examination of resource trade-offs. An examination of the user interface programming logic to see how the various student and personnel variables impact the overall system would be valuable. This area is particularly lacking in other research. The variables which have proved useful for the resource utilization model output may also provide valuable insights in this area.

Trade-off Summary. Each of the approaches considered for trade-off analysis has strong and weak points. LCCIM appears to be the most inclusive model incorporating elements of the SAT approach as well as certain submodels present in the MODIA work. The TEEM is mostly focused on the trade-offs taking place in the choice of training media and method selection. It does not take into account the broad picture of management variables which impact on the overall training system. MODIA tends to be more global particularly regarding personnel. The Navy DOTS effort which will be considered next is also strong in this area.

In terms of early training system assessment, it appears that many of the model inputs could be fed by a SAT front end. However, making the components mutually compatible or selecting the strongest parts from each would require significant programming efforts. Assistance in this area may soon be provided as a spinoff of a new CTEA contract at Fort Bliss designed to integrate existing technologies into the overall Life Cycle System Management Model. However, many of the efforts are so specialized that they may exceed the capability to develop a data base in the earliest system development stages. Research is needed on procedures for early forecasting of personnel resources. Identification of components in the resource impact portions of the models is needed as well as the effects and interactions of various training resource on the performance of the students who will be going through the courses.

Management Information

Many of the decisions directly affecting the validity of training program prediction are dependent on managerial variables as well as psychological requirements of training program optimization. This implies that early program prediction should include a means for including projected impacts of specific management decisions as soon as possible. Not only must the initial formulation of equipment and training tasks be sent to the hardware developer and training developer, but they should also interface with the probable future system managers. This may be extremely difficult at the earliest stages since many decisions cannot be anticipated until impacts of future circumstances are known. Nonetheless, a logical choice for early managerial intervention is a Life Cycle System Manager such as the TRADOC System Manager (TSM).

Four efforts of potential value for early management decisions will be presented. The first two, the TSM Guide and STEPS (Simulation and Training Equipment Planning Sources), deal with the structure within which management impacts are generated. The second two, DOTS and SNAP, deal with aids through which a manager could introduce decisions into a developing system concept.

TSM Guide and STEPS. Because of the Army's emphasis on the overall LCSMM (DoD Pamphlet 5001), ARI undertook a research program in 1976 to systematically examine the overall flow of information requirements impacting the newly created TRADOC system manager. Applied Science Associates under contract to ARI produced a guidebook which describes how training development and acquisition activities fit into the LCSMM for total system development. The guide consists of four sections. The first one discusses the main elements of the training subsystem requirements. The second section presents a generalized training developments model based on the Army Instructional System Development (ISD) approach. The third section outlines the LCSMM in a framework oriented toward training new managers and includes major milestones and events. The final section integrates training development activities with the total system acquisition process and sketches the role of the TRADOC system manager for the conduct and coordination of these activities.

The guide is most useful for a system overview; however, it does not present the manager with the specific sources from which evaluative data are to be supplied. In the context of the research already discussed, this need would be analogous to trying to apply the MODIA-user interface without the introductory manual which gives the information sources required by the program. The ARI STEPS effort now in progress is designed to meet this need by drawing together various agencies and sources to supply the data base information. At the time of writing, the STEPS effort is still ongoing but should be completed in early fiscal year 1979.

Future Research Needs TSM/STEPS. Although providing general information, neither STEPS nor the TSM guide are focused heavily at the early end of system development. They do provide an important overview of how an early prediction system must later integrate into the overall flow of military activities. Thus, they are also important for the development of managerial aids used in the concept development stages prior to milestone one of the LCSMM. Future research is still required to determine the potential impacts of an improved front and concept development system on training system development. This must wait on a more precise determination of the form which such a system will ultimately take.

SNAP and DOTS. Once a manager has obtained an overview of system impacts and potential sources of data, it is still necessary to obtain information from predictive aids in order to make choices which would impact on system development. In a global sense, such management aids are already under consideration in the development of COEA and CTEA techniques. For early system development, however, there exists a need for specific management tools. Since it is still premature to predict what degree of management intervention might be required, two such tools will be considered, each at opposite ends of the scale in terms of technical sophistication. The first tool is a graphic decision aid called SNAP (Simplified Network Analysis Portrayal) (Brown, 1977). Many manager aids have been produced for complex programs. Among the better known are simple time-line GANTT charts and sophisticated PERT/CPM techniques. For conceptual development the former is probably much too simple because options are not available in GANNT charts for consideration of alternative courses of action. The PERT techniques are powerful; however, they require an extensive effort for a busy manager. Consequently, two approaches seem reasonable for early conceptual systems. The first approach is the use of a graphic aid that can express problem complexity but does not require special resources; the second is the use of a sophisticated system by creating a transparent user interface so the program complexity is masked behind an interactive format much like that used by MODIA or CAPS. To be of value either approach should address at least six management factors:

1. The method should be sensitive to the level of complexity of the required program structure.

2. The math or analytic support required should be derivable in advance.

3. The complexity of the rationale behind decisions should be evident.

4. The output information should be explicit.

5. The applicability of the work to other areas should be derivable.

6. The resources required to implement an action should be considered.

SNAP. SNAP is a graphic flow charting procedure specifically oriented toward system development managers (Brown, 1977). It was developed as part of a project for the Defense Systems Management College at Fort Belvoir, Va. SNAP consists of a series of rules for flowcharting managerial decisions. Events in system management are characterized in terms of strings of actions, followed by evaluations, followed by decisions. Decisions in turn branch to a new series of actions. The value of the procedure is that it serves as a graphic representation of perceived impacts resulting from various management decisions. A graphic framework permits not only the decisionmakers but also the system developers to trace projected impacts. The disadvantage of the procedure is that it is heavily dependent upon the skill of a manager in identifying critical decisions. Often in a complex system, important interactions may not become evident until the entire system functions together. Thus gain from the use of a simple graphic procedure may be outweighed by the importance of global effects.

DOTS. The Navy, recognizing the importance of managerial input into training decisions, developed DOTS (Design of Training Systems) (Duffy and Stanley, 1976). DOTS' objective is to provide training management with computerized math models to assist in predicting quantitative impacts of training decisions. DOTS is based upon the input of three previously existing data base generation programs already developed by IBM for the Navy. The first includes the training system capabilities, requirements, and resources. The second evaluates the level of educational technology. The third generates the flow of the training process. These systems are analogous to tasks performed by the early stages of the MODIA user interface and its resource utilization model. DOTS however is much more sophisticated. Unfortunately, it also is very specific to the Navy command structures for training and as such does not appear to have an easy application to Army problems. The three DOTS models feed a manager model which is called the training analysis model (TRAM). For the Army, the greatest benefit of TRAM appears to lie in evaluative studies performed on the TRAM concepts during concept validation. The results of these studies show what areas in developing systems are most likely to be affected by managerial needs. There are five categories which have been derived from this analysis. They are

1. The planning of requirements including: (a) the effect of increments or decrements in resources; (b) the setting of student quotas and their integration into existing training settings; (c) the analysis of attrition effects; and (d) the analysis of new program impacts.

2. The determination of training rate feasibilities including current manpower needs and demands, and equipment and space limitations.

3. The identification of possible areas including: (a) course mixes; (b) elimination of topic areas; (c) reductions in course length; and (d) trade-off analysis.

4. The maximization of existing programs especially as they effect the cross utilization of instructors.

5. Personnel requirements as they impact on support needs and the flexibility of program structuring.

Future Research Implications SNAPS/DOTS. This area represents one of the most challenging topics for the Army. Development will have to be carefully coordinated with the current management structure and the format which is finally designed for early program development. Existing efforts appear to be highly specialized and are not readily applicable to early Army training assessment. Existing research appears to have its greatest value in identifying problem areas rather than in presenting adaptable techniques which can be used. DOTS illustrates the high level of complexity that can be developed if a careful study of the potential user needs is not made. The Army would want to move carefully in this area until the benefits can be seen to clearly outweigh the development costs.

Effectiveness Estimation

Directly associated with design trade-off and managerial decision is the concept of overall system effectiveness. In the first sections of this paper, the design concept was directly related to the ability of the system to meet a potential system threat. To evaluate whether or not a system can meet that threat, it is necessary to produce some method through which total system effectiveness can be assessed. Certain requirements must be met for such an assessment to take place. First, the system environment or battle scenario within which the action must take place needs to be determined. This is in large part a function of threat and mission definition which drives the system concept development. Due to the complexity of a modern weapon system, generally two types of effectiveness evaluations have taken place. The first consists of actual field measures taken at operational tests. The second includes reduced measures based on limited populations present during breadboard or brassboard system configurations. Neither is applicable for systems still in early conceptual stages. About the only effectiveness estimation techniques which can be used at this stage are forms of simulation. Unfortunately, most simulation efforts have used languages which are designed primarily for hardware systems such as ACSL (Advanced Continuous Simulation Language) (Manual, Mitchell and Gauthier Assoc., Inc., 1975). This simulation procedure makes use of differential equations and highly predictable hardware-related properties such as component failure distributions in order to predict total system reliability and maintainability. Another approach has been FORTRAN or JOVIAL based specialty simulations of hardware interactions with environments such as the ITEM (Interactive Tactical Environment Model) model for air defense systems. The inclusion of a human operator in such models has been a consistent problem area. One approach has been to model the human operator as a piece of highly flexible equipment, i.e., a system controller. Developed primarily by engineering groups, this approach has sought to find an optimal control model for the human operator using system control theory as a foundation. The models are usually highly complex mathematically and would be very difficult to generalize to the environment of the training manager. Another more recent approach has been to develop a specialized language specifically designed for the human factors researchers that uses task information as a basis for capturing the man/machine interaction. This approach appears to have the greatest potential for early system specifications.

SAINT. SAINT (Systems Analysis of Integrated Networks of Tasks) is both a modeling technique and a computer language (Wortman & Duket, 1978). Systems are represented as graphical networks of tasks within which one or more operators interact. Each task in a system is described as to how it is related to other tasks. A recoded graphical description is appended to the SAINT computer program for an automated performance assessment. The simulation includes both probabilistic and conditional task performance descriptions and precedence relationships as well as the collection of statistical summaries of performance characteristics. Besides possessing advantages of discrete simulation SAINT can include the full range of continuous models considered with ACSL. A major advantage is that SAINT permits changes in operator responses to system internal or external events. This makes SAINT an extremely good candidate for studying possible effects of system tradeoffs on overall system performance (Kuperman et al., 1974). Although very recent in origin, SAINT is rapidly being recognized as a major technique for modeling man/machine systems. Of value to this paper is the fact that the procedure has also successfully been used within the DAIS project to evaluate developing concepts for avionics systems. SAINT would appear to be a logical candidate for the input from a CAPS or THOUGHTSTICKER developed concept mesh. Such a linkup could provide the developer of both training and materiel with unusually powerful tools for the prediction of overall system effects and training requirements impacts. ARI at Fort Bliss already has one ongoing effort to study the prediction of training requirements based on simulated operator performance within the AN/TSQ-73 Missile Minder. Preliminary results indicate it has a high potential value for determination of critical tasks, operator loading patterns, and manning structures.

Costing

Numerous cost models exist for the weapon life cycle. The prediction of cost at early levels of system development has been severely limited by the lack of precision in early system concept formulations and data bases. This area will not be considered in detail in this paper other than to state that cost programs are being developed for CTEA and COEA analysis which hold promise of being suitable for system predictions as well. Much of the specific form of such models (as was the case for Management Information Systems) must await further development of initial concept specification techniques.

CONCLUSIONS AND FUTURE DIRECTIONS

This paper has considered a variety of developing and applied techniques which have potential use in the area of early system specification. Each of the efforts has had certain strengths and weaknesses. The major emphasis of each is presented in Figure 6. This table by no means includes all related research. Nonetheless, a pattern does begin to emerge from which it is possible to project the basic ingredients for a system that supplies assessment information to training developers. Such a system has been hinted at throughout the presentation of techniques and problems. Now it will be made specific. Figure 7 presents the first approximation of what such a system could look like based on functional areas.

A Tentative Structure for an Early Training Assessment System (ETAS)

The system begins with a perceived force deficiency and a specified threat against which a new weapon must be evaluated. Step one consists of the production of an initial hardware concept. In order to make the concept of value to the largest potential audience standardization is required. To standardize the concept form two conditions must be met. First, developers must be able to reproduce ideas in a fashion which permits different users to easily exchange information and assess the impact of different hardware possibilities. Second, output must be standardized in such a way that developmental aids such as computerized training programs can accept the input with minimal modifications. In addition, standardized specifications are needed to provide improved concept structures for potential hardware or training innovators outside the Army who would receive requests for proposals.

The first need therefore is for a concept production aid which permits a creative individual to explicitly set forth and examine hardware and training possibilities. Because of the complexity of military systems, the number of alternative design configurations can expand very quickly and often several team members must work together. Thus, the system must also serve the function of an automated designer's notebook to permit additions, changes, and exploratory efforts in a standard communicable form. Based on earlier discussions in this paper, the approach used by THOUGHTSTICKER would be an excellent potential candidate for just such a system. Adjustments would have to be made by means of a user program interface to output both task meshes and hardware information meshes simultaneously to feed the combat and training development community. Such a process does not appear beyond the present state-of-the-art. Additional psychological research is needed to give precise specification of an optimal interface structure between potential users with different styles of creative development. Such a system would present an excellent test bed for the study of creativity in system design as well as provide immediate benefits for

	ECSL	CAPS	THOUGHTSTICKER	SAT	LCCIM/TRAM	TEEM	MODIA	TSM Guide	STEPS	SNAP	DOTS	SAINT
Concept generation		X	X									
Task specification				X						X		X
Trade-off analysis	X				X	X	X				X	X
Management information		X		X	X		X	X	X	X	X	
Effectiveness	X					X						X
Costing					X	X	X					

Figure 6. Research efforts by assessment areas.

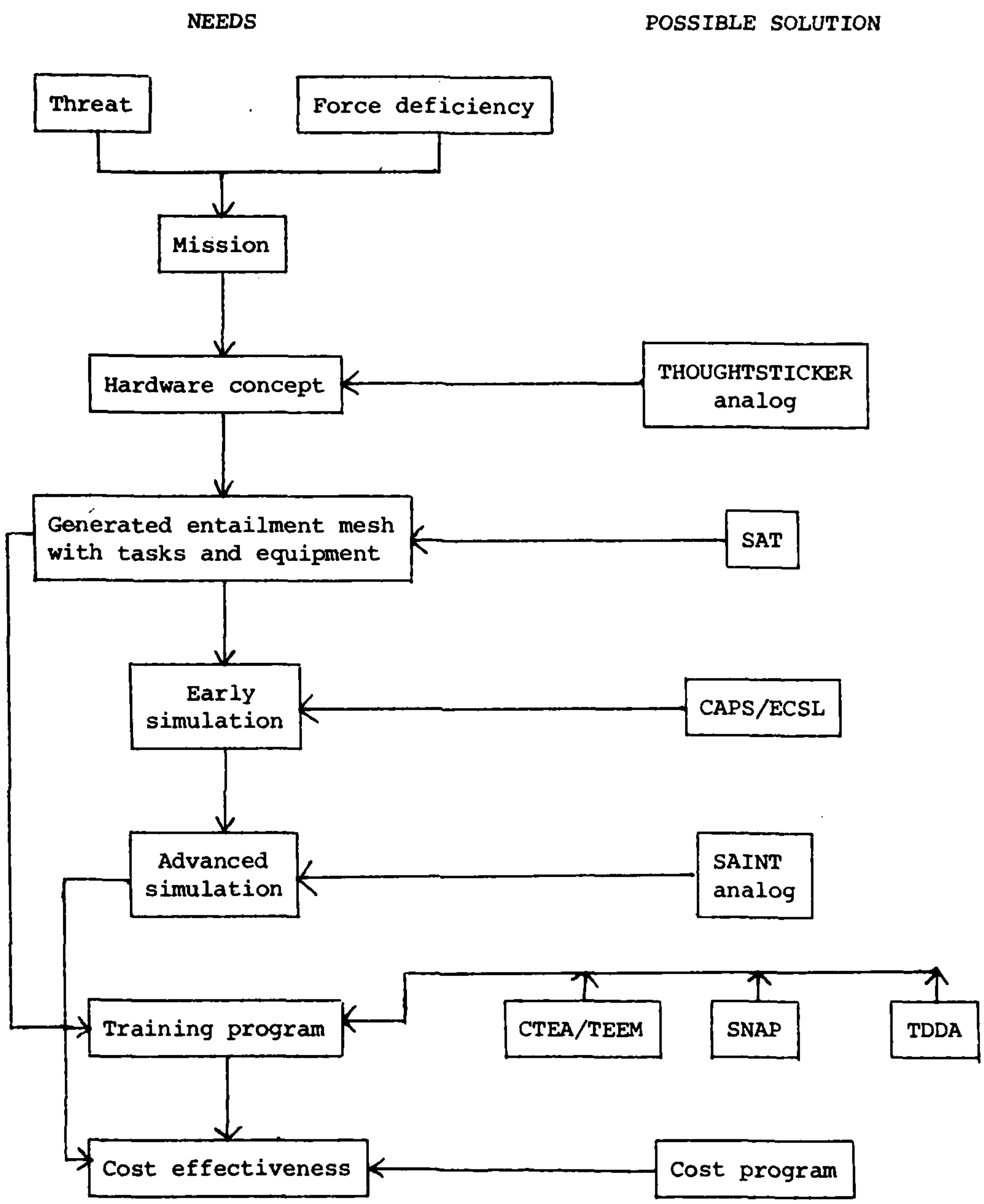

Figure 7. An early training concept development system.

system specification within the requirements of Army Reg. A109 and the LCSMM.

Once a graphic output mesh had been produced that reflected hardware and human behaviors within a given mission, the next step could begin. Since initial hardware and training concepts must be evaluated, the initial mesh of objects and operator actions would be programmed through an automated simulation interface such as CAPS. The use of CAPS would allow the designer to study the total system effect of subunit changes. This would produce early estimates of resource impacts, design flaws, and operator demands. Depending upon the level of specification, SAINT might be applied to produce automatic tracking of impacts of various task structures on the operators. This would be of value in identifying high risk tasks, true task criticality, and operator overloads within an anticipated combat environment. Modification to the initial SAINT language may be needed to simplify the coding of THOUGHTSTICKER developed task networks into a form usable by SAINT subroutines. Valuable research insights into critical components of a task description format can be gained by such an analysis. This is particularly true for determination of later training program development needs.

A second output from the graphic meshes would be input for a SAT training development approach. This method appears so well designed that an interface appears to be relatively straightforward. Adaptation of the SAT to Army uses appears to be a very viable possibility. Such a process could be of direct value in terms of early generation of training programs.

An initial training program format combined with early simulations of the hardware and operator subsystems would in turn provide input for a training manager such as the TSM. The input would reflect the requirements of COEA and CTEA documents needed at milestone one. An additional advantage of the approach is that all decisions would be documented for both decisionmakers and future development efforts. This is especially true for those efforts requiring historical information to study interrelationships between various system concepts and the actual later field performance estimates. This is critical should major battlefield simulation efforts be heavily used in assessment of field effectiveness.

Suggestions for Action

In terms of actions which can be taken as a result of this examination, there are four which appear productive. First, the researchers and developers associated with THOUGHTSTICKER, SAINT, SAT, and CAPS should be contacted to determine what advances, if any, are projected in the current state of each effort. Second, a contractual effort should take place to examine in detail agency implications and perceived benefits of such a system for the entire life cycle of a given weapon system. Third, in-house efforts should be undertaken to examine the feasibility of immediate application of SAT to the Army training development process. This is particularly true regarding the possible use of SAT in the ISD process. Finally, the utilization of CAPS should be considered across a wider range of Army problems. The ability to generate rapid on-line system models with minimal user training has great potential payoff in addressing a whole class of problems which previously had been important but of too short a time frame for professional simulation evaluations. CAPS may permit a user to directly answer the problem without having to go through outside agencies.

ABBREVIATIONS

ACSL	Advanced Continuous Simulation Language
CAPS	Computer Aided Programming System
COEA	Cost and Operational Effectiveness Analysis
CODAP	Comprehensive Occupational Data Analysis Programs
CTEA	Cost Training Effectiveness Analysis
DARCOM	Development and Readiness Command
DOTS	Design of Training Systems
ECSL	Extended Control and Simulation Language
GANTT	Charting Process Invented by H. L. Gantt
HQDA	Headquarters Department of the Army
ILIR	Independent Laboratory In-House Research
ISD	Instructional Systems Development
ITEM	Interactive Tactical Environment Model
LCSMM	Life Cycle System Management Model
LSAR	Logistics Support Analysis Record
MENS	Missions Element Needs Statement
MOS	Military Occupation Specialty
MODIA	Method of Designing Instruction Alternatives
OACSI	Office of the Assistant Chief of Staff for Intelligence
OJT	On-the-Job Training
OMB	Office of Management and Budget
PERT/CPM	Program Evaluation and Review Technique/Critical Path Method
PQQPRI	Provisional Qualitative Quantitative Personnel Requirements Information
SAT	Systems Analysis of Training
SNAP	Simplified Network Analysis Portrayal
STEPS	Simulation and Training Equipment Sources
STOG	Science and Technology Operations Guide
TECEP	Training Evaluation Cost Evaluation Program
TDDA	Training Developers Decision Aid
TDIS	Training Developments Information System
TEEM	Training Efficiency Estimation Model
TRADOC	Training and Doctrine Command
TRAINVICE	Training Device Effectiveness Model
TRAM	Training Analysis Model
TSM	TRADOC System Manager

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AR 70-27, Outline Development Plan.

AR 71-2, Basis of Issue Plans.

AR 71-5, Introduction of New System Equipment.

AR 71-9, Materiel Objectives and Requirements.

AR 381-11, Threat Analysis.

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